CLIMATE CHANGE SCIENCE AND POLICY: LESSONS FROM INDIA

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The Global Environmental Assessment (GEA) project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University, but includes substantial contributions from the International Institute for Applied Systems Analysis (IIASA) in Austria, Cornell University, Duke University and the Center for Integrated Study of the Human Dimensions of Global Change at Carnegie Mellon University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

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Publication abstracts of the GEA Project can be found on the GEA Web Page at http://www.ksg.harvard.edu/bcsia/enrp/gea. Further information on the Global Environmental Assessment project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, 79 JFK Street, Cambridge, MA 02138, telephone (617) 496-9469, telefax (617) 495-8963, Email nancy_dickson@harvard.edu.

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FOREWORD

This paper was written as part of the Global Environmental Assessment (GEA) Project, an inter-institutional endeavor based at Harvard University and the International Institute for Applied Systems Analysis in Austria. The Project's goal is to develop an understanding of the actual relationships among science, assessment, policy and management in social responses to global environmental change. It is explicitly global in scope, seeking to understand the special problems, challenges and opportunities that arise in efforts to develop common scientific assessments that are relevant and credible across multiple national circumstances and political cultures.

The core of the Project are its Research Fellows. Fellows spend the year working with one another and project faculty as a Research Group exploring histories, processes and effects of global environmental assessment. Academic year 1996-7 focused specifically on the past three decades of climate assessment experience as a dynamic learning process. Fellows papers were included in the briefing materials for the Workshop, entitled: A Critical Evaluation of Global Environmental Assessment: The Climate Experience that took place from June 22-28, 1997 at the College of the Atlantic in Bar Harbor, Maine. These papers look across a range of particular assessments to examine variation and changes in what has been assessed, explore assessment as a part of a broader pattern of communication, and focus on the dynamics of assessment. The contributions these papers provide has been fundamental to the success of the GEA venture. I look forward to seeing revised versions published in appropriate journals.

William C. Clark
Global Environmental Assessment Project Director

ABSTRACT

For more than a decade climate change has been the focus of much research and analysis. Despite the global implications of the problem the majority of research and analysis has involved researchers from industrialized countries. This paper analyzes how climate change research and analysis is performed in India, a major lesser-industrialized country. We explore the factors that play a role in shaping the capability of India to carry out, and respond to, climate change analyses. We also sketch out the links between national research and assessment capability and national policy making and how these links may have evolved and been mobilized in response to the international climate change debate. We also examine the Indian participation in, and perceptions of, the IPCC process. This allows us to reflect on the potential pitfalls for international assessment processes, and on the role that India can play in the global debate on climate change.

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ACRONYM LIST

AIJ	Activities Implemented Jointly
CLIVAR	Climate Variability
CSE	Center for Science and Environment
CSIR	Council for Scientific and Industrial Research
GCM	General Circulation Models
IBRD	International Bank for Reconstruction and Development
IC	Industrialized Countries
ICRP	Indian Climate Research Program
IGBP	International Geosphere Biosphere Program
IGIDR	Indira Gandhi Institute for Development Research
IMC	Indian Methane Campaign
IMF	International Monetary fund
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Regimes
JI	Joint Implementation
LIC	Less Industrialized Countries
MoEF	Ministry of Environment and Forests
NGO	Non Governmental Organizations
TERI	Tata Energy Research Institute
TOGA	Tropical Ocean and Global Atmosphere
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Program

1. INTRODUCTION[1]

Climate change is arguably the most important and certainly the most complex global, transboundary, environmental issue to date. The understanding of the problem is continually evolving and the uncertainties may be never fully resolved. It is therefore likely that scientific knowledge and expertise will continue to play an active role in the international policy debate.

Societal implications of climate change -- both in terms of impacts of climate change, and the economic and social consequences of various abatement strategies -- vary widely among regions and nations. A wide range of inputs, within and across nations, are key to informing and shaping international discussions in a comprehensive and equitable manner. From a national perspective, it is necessary to generate a coherent position about the relative relevance of various climate change issues for the country, and to develop appropriate national strategies for ensuring a suitable outcome of the international negotiations on climate change. The latter is of critical importance because international negotiations to date have been less about protecting the global environment, than about protecting one's own national interests with the hope of simultaneously protecting the global environment. Hence the capacity for assessing the national impacts of climate change and the national economic implications of abatement strategies is critical in arguments about who should reduce carbon emissions and who should pay for these reductions. Since the science and analysis of climate change covers the whole range of issues from data collection, data analysis, emissions scenarios, biogeochemistry, climate modeling, impact analysis, and critical analysis of abatement strategies, a national "assessment" capability requires both building skills in all of these areas, and having the ability to utilize these skills in a coordinated manner.

In this study, we define "assessment" as the dynamic, social process through which knowledge is collected, organized and interpreted, correlated and integrated, and sometimes generated to inform the process of policy-making. It is only through building assessment capacity that nations can both respond to, and actively contribute to and shape, the discussions and proposals being put forth in international fora. From a national perspective there are two dimensions to assessment capacity: a *reactive* capacity which can be instrumental in the evaluation of national implications of new scientific findings and international policy initiatives, and a *proactive* capacity designed towards a more active shaping of the international policy process through expert input, participation and dialogue. The past decade has seen an rapid increase in the both these capacities in industrialized countries (ICs). In less industrialized countries (LICs) climate change remains a low priority issue which garners little political attention or research funding. Consequently, there is a widening gap between the capacity of LICs and ICs in performing climate research and assessment.

It is quite clear by now that LICs and ICs differ dramatically in their perspectives on climate change. These differences are centered around the attribution of responsibility to countries based on their historical emissions and threaten to dominate much of the future discussion on who will pay for future reductions (Agrawal and Narain 1991; Dasgupta 1994; Goldemberg 1994; Sebenius 1994). ICs tend to view the climate change as a global problem whose ultimate

solution lies in the world wide use of environmentally friendly technology. LICs on the other hand are unpersuaded by IC calls for international cooperation, particularly since ICs have little to show by the way of serious efforts at their own national emissions reductions. Furthermore, resolution of the climate problem based on technological change inherently favors ICs over LICs. From an LIC perspective the reluctance of ICs to engage in serious discussions regarding technology transfer further highlights the presence of a hidden economic agenda lurking under a global "green" cover. Any attempt at the future resolution of the climate problem will have to face these differences among nations. It is in this context that the widening gap in the nature, magnitude, and diversity of global environmental research and assessment activities between LICs and ICs becomes very significant.

This article analyzes how climate change research and analysis is performed in India, which is a major LIC and a key player in the global debate on climate change. Throughout the paper, we hope to provide, through examples, a synoptic view of the state of the national and international scientific and analytical capability vis-à-vis climate change and explore the factors that play a role in shaping the Indian assessment system. We sketch out the links between national research capability and national policy making for India and how these links may have evolved and been mobilized in response to the international climate change debate. An understanding of the Indian assessment system allows us to draw some implications for the international processes by which science is linked to policy. It also allows us to reflect on the role that India can play in the global debate on climate change.

2. EVOLUTION OF CLIMATE CHANGE RESEARCH AND ANALYSIS: A NORTH-SOUTH DIVIDE

Much of the early focus of climate research was on the "scientific" nature of the problem, primarily in the realm of the physical sciences. Over the past decade, as international interest in the issue has increased, there has been a significant shift in the level and nature of research activity. More recently, as a scientific consensus has emerged on the anthropogenic causation of climate change and the locus of the policy debate has moved towards strategies for reduction of greenhouse gas emissions.

Over the years the debate has also attracted many newcomers to the field, substantially widening the range of issues under discussion (Schneider 1997). The discussion has increasingly come to involve natural and social scientists interested in understanding the ecological and societal consequences of climate change, and in analyzing measures for mitigation of climate change. For many researchers, physical, natural and social scientists alike, the most exciting research and analysis lies at the previously unacknowledged intersection between their own research areas and those of their colleagues in other disciplines. The search for "policy relevant" information and the emergence of scientific bodies such as the International Geosphere Biosphere Program (IGBP), and advisory bodies such as the Intergovernmental Panel on Climate Change (IPCC), have been instrumental in increasing scientific collaboration across disciplines and, to a lesser extent, across national boundaries.

Despite this upsurge of interest and qualitative shifts in the disciplinary structure of climate change research, the majority of research and analysis has involved analysts from ICs, and has focused on issues directly relevant to these countries.[2] Increased public concerns about climate issues, increased funding for research and the development of new institutional structures during the past decade has resulted in substantial enhancement of national analytical capabilities in most industrialized countries. Furthermore, the interactions among these researchers have been actively fostered by government funding agencies at the national levels, and by the enhancement of collaborations through international scientific programs such as IGBP and WCRP (World Climate Research Program). This has resulted in the establishment and strengthening of cohesive national and international communities of interdisciplinary researchers in the North.

In LICs, governments generally have limited (financial and human) resources and other competing goals which has resulted in low levels of funding for climate research and analysis. In some countries such as India, there is a clear recognition among some of the science policy elite that internal assessment capability is of primary importance. India has been able to fund a small amount of internal research related to climate change on topics that are deemed to be of strategic importance such as emissions inventories of greenhouse gases, and predictability of the monsoon under a changed climate regime. However, internal funding for climate related activities in India is small -- only a tiny fraction of the funding in many countries of the industrialized world. Consequently, the number of climate researchers in LICs is much smaller than in the ICs. Scientific research is rarely organized or cohesive at the national levels in the former countries, let alone among them. At the same time, the inclusion of multiple voices and disciplinary perspectives is far more limited in the LICs than in the ICs.

At the international level, collaborative scientific programs, particularly those carried out under the umbrella of IGBP and WCRP have involved a few scientists from less industrialized countries. However, major international efforts aimed at furthering research activities in developing countries such as IGBP's START have been "slow to start" due primarily to funding constraints (McCarthy, 1997). Consequently, there is a widening gap in the magnitude and diversity of research and assessment activities related to the global environment between less and more industrialized countries.

There have been almost no concerted attempts to build a Southern community of researchers, although regional programs such as the Asia-Pacific Network and regional START centers have begun to take occasional tentative steps. Even more important, the international networks of researchers that exist in the South are invariably in conjunction with and connected through researchers from the North - there is no exclusively Southern network whose focus on issues is not shaped by Northern interests. The establishment of such communities could be instrumental in developing a shared, proactive approach by Southern researchers to shape the international research agenda and bring much needed authoritative LIC perspectives to the climate change debate.

The Intergovernmental Panel on Climate Change (IPCC) reports which provide the scientific and technical basis for international negotiations, also reflect the skewed nature of the global scientific and analytical base. This is particularly important because the IPCC is the primary

consensus document which serves as a foundation for international negotiations because of its inter-governmental nature, as well as the direct links it has to the UN Framework Convention on Climate Change (UNFCCC), both administratively and through the involvement of national personnel.

At a broader level, an international community predominantly composed of experts from the North may be disconnected from the particular needs, realities and interests of LICs.
Studies on cross national and cultural perspectives on risk have shown that scientific problem definitions and paradigms can be framed in ways that reflect underlying cultural presuppositions (Jasanoff, 1996). In the context of climate change, biases introduced by disproportionate participation of experts from ICs can implicitly shape the understanding and acceptance of scientific issues. This may serve to dilute equity issues through climate change analyses done from the perspective of an abstract global citizenry or may implicitly serve interests of the political north by focusing on certain issues while ignoring others. Scientists and policy-makers in less-industrialized countries are not likely to be persuaded by the ability of an "objective" global research community dominated by experts from industrialized countries to raise a comprehensive set of issues representing the interests of all the citizens of the globe.

In this paper, we analyze the role that various groups and institutional actors play in India's climate assessment system. We describe how climate science and analysis is performed and organized in India, and how Indian researchers interact among themselves and with national policymakers. The Indian assessment system is situated within a pervasive international context where the scientific might and economic goals of industrialized countries defines the both structure and the language of the international debate. We therefore examine how India's ability to perform research and develop a national assessment capability is shaped by these international inequities, and how Indians in the scientific and policy communities have responded to international pressures related to climate change.

3. INDIA: A CHANGING CLIMATE

In 1991, the newly formed Congress-I Government headed by P.V. Narasimha Rao (the fourth in two years), agreed to a structural adjustment program as a conditionality[3] for much-needed loans from the IMF/IBRD[4] This required government agreement to a program of economic "liberalization" which included substantial changes in industrial and financial policies and the move towards a free trade policy. This program marked the official ratification of a radical shift in India's economic policies.

India's response to Rio and beyond has to be seen in this context. Since the beginning of the decade Indian policy makers have been actively engaged in navigating the transition to an economically liberalized state where the perceived primary determinant of success is economic growth. In national and state planning, the overwhelming focus is on rapid industrialization, and in sporadic bursts, on the development of infrastructure (such as power and telecommunications) necessary to support an increasing industrial production.[5] The independent Indian press, particularly the English language media, now devotes much of its attention to

economic activities shaped by elite national and international interests. Unfortunately (for most Indians), these "liberalization" and restructuring programs were implemented without much analysis of the possible consequences of a sudden shift in policy. As in most other countries[6], economic restructuring in India has been far from smooth, and has been punctuated with a number of major political scandals.

Climate change arrived on the international scene at a time when India was undergoing these monumental shifts in economic structures. The resulting intellectual ferment and political turmoil has left climate change at the trailing end of international issues visible on the Indian horizon.[7] While there are occasional media reports on the work of Indian scientists, and the Indian parliament has been reported to have discussed the issue once, there is little indication that climate change carries with it the public interest or political debate that biodiversity issues (and to some extent the Montreal Protocol) generated. This can be attributed in large part to the economic aspects that became very transparent as the Dunkel draft on Intellectual Property Regimes (IPRs) was submitted to the Uruguay round of the GATT in the early '90s. There was a vigorous debate in India at all levels – from Delhi elite to impoverished rural farmers – predominantly about the impact of such a regime on expropriation of indigenous knowledge (Sainath 1997). It must also be recognized that the IPR/GATT debate fit in neatly with the national ferment about economic liberalization. The flurry of activity surrounding economic issues and other internal political concerns has crowded out issues related to the global environment. In other words, the attention given to changes in national economic climate has overwhelmed any concerns regarding global climate change.

While a number of NGOs are continuing their focus on the environment, their activities often target local and regional environmental issues which seem to have gained a measure of prominence in urban public life. For example, Center for Science and the Environment (CSE), which spearheaded the international equity debate related to global climate change with its seminal paper (Agrawal and Narain 1991), has chosen to devote most of its attention to rapidly worsening urban air and water pollution.

To be sure, the importance of climate for its economy and the well being of its people is well understood by most in India. India receives close to 80% of its annual rainfall in the monsoon season and the Indian economy is inextricably linked to the annual South Asian Monsoon. Agriculture which accounts for 30% of India's GDP and close to two-thirds of its labor force is critically dependent on the monsoons. Failures in Monsoons can have severe effects on other economic sectors as well, and are a matter of great political concern. Predictions of the magnitude and timing of the next monsoon issued by the Indian Institute for Tropical Meteorology are factored into deliberations towards allocation of resources in the Indian annual budget (Shukla 1997). The past several years have seen better than average monsoons and good harvests, contributing perhaps to the reduced level of attention paid to climate issues.

3.1 India: The Research Climate

Subsequent to independence from British colonial rule in 1947, the Indian government invested heavily in scientific infrastructure with the view that a strong science and technical base was key

to industrial development and self-reliance[8]. This included setting up independent institutes of higher education in science and engineering as well as a complex of national laboratories under the umbrella of the Council of Scientific and Industrial Research (CSIR). India now has the third-largest scientific community in the world.[9] This, then, serves as a backdrop for understanding the ability of Indian science to marshal at least some scientific manpower for climate change research and assessment.

India remains among the poorest countries in the world, with a per capita annual income of about $350. The total science and technology expenditure of the Indian central government for the financial year 1994-95 was approximately US $ 268 million. (In comparison, the US federal govt. R&D expenditure for 1994 was over US $ 62 billion (NSF 1996)) This severely constrains the resources that can be allocated to developing a sophisticated infrastructure for scientific research. In a sense, this creates paradoxical situation - India has an education system that is relatively efficient at imparting education with limited resources, but is lacking a scientific infrastructure that allows scientists to engage in cutting-edge resource-intensive research.

3.1.1 Size and structure of India's climate change research activity

The number of climate change researchers and analysts in India is relatively small - the number of researchers involved on a continuing basis on all climate-change-related activities is less than a hundred. Research groups are clustered by discipline as well as by geography; most of the groups are in a few cities (Delhi, Mumbai, Bangalore and Pune). There is also a relatively clear institutional division between those working in the realm of the physical and natural sciences and those working on policy related issues. For the purposes of this paper we refer to scientific work to primarily involve the physical and natural sciences. Analysis that seeks to inform policy decisions is termed as policy analysis. There are no institutions in the country where substantial climate change research is being carried out both in the scientific and policy end of the problem. Scientific work on climate change tends to be focused on particular areas of interest reflecting both existing strengths and strategic choice of research areas that are seen to be relevant for India. This work is mainly carried out in governmental laboratories of the CSIR, and academic research institutions by individuals or small groups. Policy analysts working on climate change issues on the other hand tend to be involved in a few large institutional efforts primarily by NGOs and academic institutions.

The largest single disciplinary group of climate change researchers in India are climatologists and meteorologists. This is not surprising given the long tradition of this field in India (Sikka 1992). Expertise in climatology is centered in the Indian Institute of Tropical Meteorology in Pun, Indian Institute of Technology, Delhi, and the National Institute of Oceanography in Goa, although there are individuals and small groups working in this field in a number of different institutions (Montclim 1996)). As we discuss later in this paper, some of the efforts of this community are now being coordinated by the Indian Climate Research Program. There are a number of other scientists - physicists, chemists, biologists, ecologists and agronomists - who are involved in various aspects of climate science ranging from atmospheric modeling to field experiments. Many of these scientists or groups work in a relatively independent fashion, though there are often institutional connections between them - the National Physical

Laboratories, the Indian Agricultural Research Institute and the Indian Institute of Science have a significant body of researchers working on core areas specific to the institutions. A third nodal center for climate related scientific research is the Indian Institute of Science in Bangalore, where research is carried out on ecological and land-use-issues related but not exclusively linked to climate influences.

Policy analyses of the social, economic and technological aspects of climate change involve primarily a few large NGOs, and some academic institutions.. The former group is involved in the production of macro-level studies focusing mainly on climate change abatement and there is very little work on impacts of and adaptation to climate change. The two largest efforts are being carried out in the Tata Energy Research Institute (TERI), a mainstream NGO/think tank in New Delhi and the Indira Gandhi Institute for Development Research (IGIDR), a national research institute with the official status of university. In addition, two other Delhi NGOs which focus on regional and local issues are sporadically active in the climate change arena (Center for Science and the Environment (CSE) and Development Alternatives). With the exception of IGIDR, little amount of work related to climate issues has been carried out in the large number of Indian social science research institutions, which in many cases provide scholars with enhanced opportunities for research environments compared with universities[10]. In addition, some of India's top academic technical and management institutes have one or two policy analysts focusing on climate change.

The small group of scientists in India perceives a constant barrage of information on the science as well as the policy front. There is a clear sense among the researchers of being overwhelmed by a process in which the large number of researchers from other countries (most notably US, Australia, Netherlands) lead the charge. In large part. this drives the need to develop an Indian perspective in response to external research and proposed policy initiatives that have implications for India. Given the resource constraints (see discussion on funding, Sec. 3.3), research in India focuses almost exclusively on national aspects of the climate change discussions - whether they be emissions, abatement or impacts. The small community scientists and policy-analysts in India are also often forced to broaden their research capabilities. This is particularly true for the senior people - they also tend to be over-subscribed and play multiple roles: as scientists and assessors, as advisors to the Indian government, as members of the IPCC or other international bodies. While this places limits on the time that the top cadre of scientists can spend carrying out active research, it also allows them to gain a comprehensive view of climate change, and to develop a well-informed stance on many issues.

Within the climate science community, there is only some collaborative activity among scientists, but generally this is at a small scale involving a few researchers or groups. This could in part be due to the fragmented nature of Indian science.[11] In addition, lack of resources do not permit regular informal interaction at venues such as workshops and conferences that is vital for exchange of ideas within and across disciplines or building of networks- not many researchers can afford to routinely to go to national conferences, leave alone international meetings. In some cases, though, cross-institutional collaborations may be present, as in the example of a major initiative coordinated by the Center for Global Change at the National Physical Laboratories in New Delhi. This large inter-disciplinary group of scientists have been engaged in an inventory

initiative for the past six years and has produced a series of detailed technical reports on India's greenhouse gas emissions(Mitra 1992; Mitra 1996).

There are frequent but limited interactions between the science and policy analysis community. This is part facilitated by the geographical location of certain groups - a significant number of governmental labs, academic institutions, government offices and NGOs are situated in Delhi. Collaborative activities among these groups are rarely catalyzed by institutional or programmatic structures. There are a number of collaborations among various researchers and group but these are mainly set up at personal initiatives. The few multi-group/multi-individual studies on climate change generally draw upon the independent expertise of various groups/individuals rather than on prolonged, integrative, interdisciplinary efforts. For examples see (Achanta 1993; ADB 1994).

The linkages between climate analysts and the government in India are less institutionalized than in countries such as the US (which has a long history of formalized links first developed under the National Academy system)[12]. Scientific bodies in India are not organized in actively providing policy advice to the government and links between scientists and policy makers often operate in an informal manner. Policy-making bodies solicit advice from scientists on a more immediate "need-to-know" basis. The actual processes by which the advice is solicited are dependent on the particular issue, the personalities involved at the policy level and their level of engagement in the issue.

In the realm of climate change, to the best of our knowledge, no comprehensive, inter-disciplinary, authoritative document to inform the government (such as the 1992 US NAS study) has been produced. The Ministry of Environment and Forests (MoEF), which is in charge of the climate issue has tended to seek advice from Delhi NGOs (TERI, CSE) and academic institutions (IGIDR) whose leaders have built a special rapport with the ministry over the years. In addition, the ministry might also seek technical advice from high level experts employed in government research institutes and universities. These researchers might be called upon to provide rapid advice on a particular issue, as and when needed, produce position papers upon request, and to participate in more structured activities (committee meetings etc.) to inform and guide policy makers prior to UNFCCC or IPCC meetings. An Indian minister for the environment was also known to personally discuss specific issues with some scientists, policy analysts or activist NGOs, especially prior to international meetings. However, there seem to be few systematic channels and institutionalized procedures by which MoEF and the experts interact. Prior to the Rio convention there seems to have been a greater interest within the government to stay engaged in climate change, which in more recent times appears to have eroded. This has led to frustration among many in the research community about the lack of interest in climate change issues at the policy level and the minimal role that analysis seems to play in India's stance at the negotiations.

3.2 Climate for coordinated research

As mentioned earlier, the climate science community in India is relatively variegated and researchers are not very well connected to one another. However, Indian researchers have

sometimes responded to the challenges created by the international scientific advances and policy debates on climate change. There have been two major scientific initiatives launched by the Indian research community, the Indian Methane Campaign which began in 1991, and the Indian Climate Research Program which was initiated in 1996. In each case the policy relevance of the efforts was clearly perceived by the scientists, and in each case there was the sense that the work was of significant national interest.

3.2.1 The Indian Methane Campaign

While the importance of methane as a greenhouse gas was recognized in the early on methane stepped on to the greenhouse policy agenda only in the late 1980s and early 1990s (Hogan, Hoffman et al. 1991). As comprehensive regional and global inventories of greenhouse gases started being developed, the difficulties in developing precise estimates for sources of methane soon became apparent to some members of the policy analysis community.[13] Furthermore, discussions of methane emissions were potentially contentious. Internationally, the Bush Administration (USDJ 1991) raised the stakes in the buildup to Rio by calling for comprehensive abatement of all greenhouse gases, in what some saw as a move to take greenhouse credit for CFC reductions enacted under the Montreal protocol (Grubb et al. 1991).[14] This sharpened a growing north-south divide on allocations of global emissions responsibility. Many in the south felt that placing methane emissions from rice cultivation and other primarily southern, subsistence activities on a par with primarily northern "luxury" emissions of carbon dioxide from automobiles and industrial activities unfairly penalized "subsistence" activities (Ahuja 1992).

The Indian Methane Campaign (IMC) was launched in 1991[15] in response to internal concerns regarding the attribution of methane emissions to Indian sources by studies done abroad. The apparent catalyst for the initiative was a detailed study done by the US EPA (EPA 1990) which placed emissions of methane from Indian sources of rice paddy at 37.8 Tg/yr (1Tg = 10^{12} kg), a significant fraction of the estimated global source of 100 Tg/yr.[16]

There were a number of distinctive features of the IMC. It was one of the first scientific initiatives on climate change related issues with initial funding provided by the Indian government, and was seen to be of direct relevance to a national policy stance. The campaign involved close to fifty researchers from sixteen research laboratories and measurements were carried out in seventeen different sites. The organisers had recognized that gathering scientific data and developing assessment capability requires a community of researchers who are actively networked, and work on projects with focused goals (CSE 1995).

There was a recognition among the scientific community both about the political context of data acquisition and assessment, and the policy relevance of the task being undertaken. More broadly, the initiative reflected a desire for developing indigenous capacity for collection and assessment of targeted scientific data in the face of growing international pressure related to climate change. Since 1991 the campaign has moved from focusing on methane alone to building an inventory for all greenhouse gases using methodologies suggested by the IPCC, in an effort to provide national communications due to the Conference of Parties in April 1997.

Earlier work done in India by Indian scientists (Parashar, J.Rai et al. 1991) had suggested methane emissions to be far lower than those calculated by the EPA. Since emissions of methane vary quite significantly with climatic variables, soil chemistry and biology, and farming practices, the IMC sought to make its own measurements in quantifying Indian emissions of methane from rice paddies. The IMC found emissions from rice in India to be about 4 Tg/yr (3-6 Tg/yr), far lower than those calculated in the EPA study. These estimates also implied a much lower world wide source for rice paddies than those potentially controversial though there has been very little debate in the open literature on the topic. Indian scientists have published papers explaining the reasons for the differences, which are rooted in the specifics of Indian soil conditions, farming practices and in the differences in schemes for extrapolating from site specific measurements to a national budget (Sinha, 1995). Further work based on standardized extrapolation schemes developed by the IPCC has also not altered these estimates by much (Mitra 1996). The broader international research community has effectively ignored the Indian findings, and there has been little open debate either refuting or supporting the work[17] [18]

3.2.2 The Indian Climate Research Program

Research on the monsoons has been a major preoccupation of atmospheric sciences in India, dating back to the classic "Rainfall of India" by (Blanford 1886). In more recent times, a number of researchers in universities, and government research laboratories have spent careers investigating fluctuations in seasonal and sub-seasonal monsoonal patterns over land and their links to synoptic scale atmospheric circulation patterns. Over the years Indian science and scientists have contributed substantially to the scientific understanding of the monsoon circulation system.[19]

During the past decade the World Climate Research Program (WCRP) launched a number of worldwide collaborative efforts in core scientific areas. One such effort, the Tropical Ocean Global Atmosphere (TOGA) Program focused on the influence of the warm western Pacific Ocean on the global atmosphere, and advanced scientific understanding of the ENSO phenomena. As a followup to TOGA, WCRP has launched CLIVAR (CLImate VARiability), with the Asian Monsoon as one of its thrust areas. The CLIVAR program will attempt to build enhance the understanding of seasonal and interannual variability with the ultimate aim of providing seasonal forecasts of the Asian Monsoon (Shukla 1997).

Scientists from India participated in TOGA, and are also involved in CLIVAR. Participation in TOGA served as a trigger for the launching of a national research program on climate -- the Indian Climate Research Program (ICRP) – because "there was widespread concern that extent of participation and contribution [in TOGA] was not commensurate with the importance of the subject to the nation, the talents and expertise of scientists and resources available within the country" (DST 1996). Moreover, ICRP is an effort to consolidate the efforts of Indian scientists under a single institutional umbrella, and to co-ordinate Indian research efforts with those of WCRP.

The ICRP research efforts focus on developing the scientific understanding of climate variability over seasonal and inter-annual time scales. The ultimate goal is of monsoon predictability over seasonal time scales through modeling, and the seemly and analysis of data sets. Research on regional anthropogenic climate change is also envisaged, though less emphasized. At the "user" end ICRP plans to investigate the links between monsoon variability and predictability and crop yields.

ICRP is seeking to consolidate long history of research on different elements of the Monsoon with the hope of providing information critical to the needs of an enormous number of decision makers. A small but coherent inter-disciplinary research group involving meteorologists, oceanographers, ecologists, and agricultural specialists seems to be emerging. Further more, this group is seeking to build scientific networks within India, which is vital for community building in a complex research area. The group will attempt to do this through focused programs, regular meetings and conferences and increased funding for training of young researchers (ICRP, 1996). However, as we note later funding constraints may limit what is possible for this ambitious effort.

3.2.3 Policy Analysis

Policy analyses of climate change are topical and focus on specific issues -- there seem to be no comprehensive (or integrated) assessments of climate change issues as they relate to India. A large fraction of the analytical focus on is abatement issues – "top down" emissions abatement (Mathur and P.Bhandari 1993), specific policy instruments such as Joint Implementation (Pachauri 1994) and energy efficiency measures (Parikh and Gokarn 1993).There has been some macro-economic modeling of carbon abatement as well. There has been relatively little work on the impacts of climate change, and the few existing analyses focus almost exclusively on coastal zones and agriculture. A majority of the work on impacts has not been published within India or abroad. Furthermore, analysts have not even begun to look at adaptation issues. The lack of focus on impacts and adaptation may seem rather surprising for a country whose economic well being is so tightly connected to the vagaries of year to year changes in climate, but the skewed nature of the analyses might be easy to explain. First, impact assessment is a resource intensive exercise requiring expertise and investment in a number of different research components. For example, traditional models of climate change impacts on agriculture, require the ability and resources to generate climate scenarios (preferably using GCMs), build regional models for specific crops, and gather extensive data for model calibration. Second, funding for policy analyses which comes mostly from foreign multilateral and bilateral agencies tends to be allocated for analyses of abatement options, this fits quite well with the expertise of analysts who are predominantly economists and engineers. More importantly, foreign funding helps keep issues on the funding agencies agenda alive in Indian science and policy circles. Through continued funding of specific topics and conferences, multilateral and bilateral agencies attempt to make policy analyses in India reflect their own (dominant) views of India's global role in climate change policy.

3.3 India: Funding Climate

It is often unrecognized that climate research requires a vast scientific infrastructure and monetary sponsorship. Assessments of impacts and policy options build upon scientific knowledge that has been incrementally assembled over a number of years by an active inter-disciplinary network of scientists. While there are few opportunities for scientists in LICs to use pre-existing work for specific applications (e.g. regional GCM outputs), in a majority of the cases regional studies require specific knowledge tailored to the region. Regional studies may require both resources that researchers may not have and links into scientific networks that require a long time and much effort to build.

Scientific research related to climate change in India is funded mostly internally, with a majority of the funding provided by CSIR through its support for the system of national laboratories. Specific programs such as the Indian Climate Research Program are funded through national initiatives under the Department of Science and Technology. When scientific work has direct relevance to policy issues, such as the research on emissions inventories, some international sources of funding such as GEF funds an be leveraged. However, GEF funding is limited to policy related activities and funding for scientific research and capacity building in the sciences is not encouraged. The scientific community is connected to international programs such as IGBP and WCRP. However, these programs do not provide funding for scientific research and reserve small amounts of money for travel to conferences.

Climate scientists in India do not have access to the levels of funding and the resource base which their western counterparts can draw upon. Funding for climate change related activities in the US, Europe and Japan exceed funding levels in India by at least two orders of magnitude. As an example, the five year budget (1997-2001) for ICRP is approximately $2.5 million -- this includes funding for data gathering ($1.1 million), data analysis ($700K), and impact assessment ($200K). By contrast the US Global Change Research Program spends between 65-80% of its annual $1.7 billion budget on climate change. Funding for research deemed policy relevant is between $35-40 million (Harris, 1997). This is at least two orders of magnitude more than the amount earmarked by ICRP for the same purpose.

Indian researchers who work every day under budgetary constraints know well the implications of such financial limitations for their work. Constrained budget conditions can set up a competitive atmosphere where researchers vie for a piece of the pie.[20] In addition, research progress can be inordinately slow because of the lack of resources to order hardware and software, as needed, and also because the careful control over finances prevents rapid action. Almost all scientists in India learn to make do with the limited resources, but in the end, the potential of the work may be limited artificially by this environment.

A leading monsoon modeler and IPCC lead author described to us his ongoing (unsuccessful) five year struggle to obtain a work station computer which would allow his research group to run General Circulation Models. Despite excellent credentials and collaborations with some of the best scientists in Europe and North America, his requests for funding have been repeatedly turned down by national and international funding agencies.[21] He and his students currently use

workstations, as and when they can, at the only institutional cluster which has 8 workstations for 2500 students and 1000 faculty. The inability of a world class modeler working in one of India's best institutions, to obtain $10,000 for a computer symbolizes in a poignant way the hurdles that many researchers from LICs face in working on an issue such as climate change which requires substantial material resources. And Indian scientists are the more fortunate ones among most LICs.

A resource constrained atmosphere is not very conducive to developing a national research community and building up coherent programs with a long-term perspectives. To the extent that this has happened in India, the credit has to go to the bureaucrats and scientists who have more vision than finances.

Foreign funding serves as the main engine for climate change policy analyses in India. This is provided by multilateral agencies such as the Asian Development Bank, Global Environmental Facility, and bilateral donor agencies such as USAID, NORAD, CIDA as well as large private foundations (such as Ford and Rockefeller foundations). The Publications that result are either in the form of working papers, conference reports, and books (Achanta 1993; ADB 1994).

In India, as in other LICs foreign funding allows recipient groups to quickly build a national and international reputation. This in turn results in increases in foreign funding for the organization of conferences, subsequent publication of conference reports and further consolidation of a group's reputation. In addition, research links with other international groups can be established and maintained. Locally, a high profile facilitates links with other national scientific institutions, helps in establishing contacts within government ministries, and in attracting local Indian talent and talent from abroad. Leaders of such groups are widely sought after in international policy fora, which allows them to bring their perspective to international discussions. It also allows for increased participation of younger researchers who then can ride on the "coat-tails" of their bosses. This provides perhaps the only way for younger Indian analysts (who have not been trained in the west) to break into the international circuit, and groups such as the IPCC.

On the other hand, the donor driven nature of the enterprise means that the work may be of limited use for internal policy or capacity building since donors may have specific agendas that need to be satisfied.[22] Consequently, policy research can take on the flavor of consultancy tailored to the donor agencies requirements which seem to rise and fall in synchronicity with the appearance of specific issues on the international agenda. Occasionally multiple reports might be written on the same issue (sometimes by the same institution) resulting in an enormous loss of time, effort and talent that might be better spent on a breadth of topics.[23] In many cases, analysts duplicate work and often make no reference to each others work even when their papers are on the same topic reflecting perhaps an unhealthy competitive atmosphere brought about by funding imperatives. Finally, as mentioned earlier, external funding forces the focus on one set of issues to the exclusion of others.

Funding agencies may not always fund dissemination of reports and books, making it difficult for other researchers to find them. At least one major policy research institute (IGIDR) in India has made substantial efforts to distribute its reports outside India, but limited success.

Consequently, this may limit the broad dissemination of research findings and ideas. This may also have the perverse consequence of discriminating against younger scientists who in most cases do not have personal connections to get copies of important documents. It is also difficult to get access to international journals which are very expensive and therefore afforded by only a limited number of institutions To avoid this, many Indian scientists publish in Indian journals to communicate their work to an Indian audience; unfortunately, these journals may not be very well distributed outside India.

4. INDIA AND INTERNATIONAL ASSESSMENTS

Prior to the formation of the IPCC, Indian scientists and analysts were not involved in efforts to raise awareness about climate change in international policy circles. [24] The formation of the IPCC opened up possibilities for formal participation of Indian scientists in the global policy debate for the first time. Some have suggested that the very formation of the IPCC, was in part to allow for the participation of a wider community of scientists, one that was more representative of the world whose problems it was seeking to address (Schneider, 1996). The first assessment report released in 1990 saw very little participation of third-world scientists in the IPCC recognized this shortcoming and commissioned a report to help seek ways to increase developing country participation.

The second assessment report which was released in 1995 had a slightly higher participation from developing country scientists and analysts. In part, this was due to the reorganized structure of IPCC as the panel decided to place greater emphasis on issues relating to mitigation, impacts (Working Group II) and socioeconomic implications of climate change (WG-III) than it had in the past. Furthermore, the higher-profile of the climate change discussions and the debate regarding the first assessment report was responsible for increasing the LIC participation in literature and other international fora (Parikh 1992). This may also have resulted in the researchers being invited to join the Second Assessment Report. Indian participation in the second round of the IPCC increased significantly, in large part due to increased participation in working groups II and III. Participation in the scientific assessment of working group I continued to remain at a low level (See table 1).

Although LIC participation in IPCC has improved somewhat, it is clear (and a matter of much concern) that the participation continues to be heavily skewed in favor of some ICs. This is partly unavoidable, because the IPCC reviews the state of the current literature, and because active researchers are (in theory) best suited for the task of this review.[25] It also seemed to some Indian researchers that LIC input does not really shape the content (and process) of the IPCC assessment. To a limited extent, though, some of the Indian participants felt that they were successful in at least bringing their concerns to the IPCC table. However, this observation needs a cautionary note - regardless of their intentions and efforts, a few people cannot represent the interests and concerns of a diverse country like India.[26] To be sure, participation alone seldom guarantees diverse representation of views and perspectives. It is more important for participants in international processes to be engaged in an active internal dialog in their home countries, which may be a precondition for representing a diverse range of national perspectives.

For many of the Indian participants in the IPCC, this assessment process is connected to, and part of, a larger continuum of international science/ policy/environment discussions in which they are involved. This can allow them to bring a multidisciplinary perspective to the IPCC process – which is reflected in the fact that some Indians are participants and reviewers for more than one working group. In contrast, a larger fraction of participants from ICs come from specific disciplines and may view the content and the role of the IPCC less broadly. The sheer numbers of the latter in IPCC may have serious implications for the inclusion of broad and multiple-national perspectives in climate change discussions. Skewed participation may further consolidate dominant disciplinary perspectives that are rooted in particular national and cultural ideas.

Formal assessment processes such as the IPCC, do not translate easily into the Indian science policy setting. The IPCC assessment process requires resources, infrastructure, and operating procedures within the governments of participating countries. The process implicitly assumes that countries can effectively coordinate their efforts behind a nodal institution and that quick administrative and research response times are possible. This is difficult for India - where most of the ministries in India (such as Power, Heavy Industries etc.) are caught up with other concerns and climate change is low on their priority list (if at all); a limited number of administrators and researchers are involved in multiple activities and cannot always find the time for quick response and detailed consideration that the IPCC process often needs. In India all issues related to IPCC fall on a single person working in the Ministry of the Environment, who also works on other issues addressed by the Rio convention.

The lack of coordination and institutional infrastructure can result in a number of disconnects between national scientific input and international assessments. For example, the IPCC sends personnel requests for authorship and review, requests for feedback on IPCC procedures, requests for consultation on chapter headings and outlines to the IPCC contact points. For several of these functions the Indian IPCC interface has been inadequate in the past and led to a number of undesirable outcomes: experts were not contacted for participation in the IPCC even when in country expertise existed; the same experts were contacted for review of multiple working groups; unnecessary delays were introduced in the process.

Most members of the Indian research community are acutely aware of the political nature of the international assessment process, and how this process might fit in with the larger international context. The focus is not just the N/S divide on climate change emissions and responsibility, but a clear recognition of the N/S inequities in the assessment process, as well as the broader context (such as globalization) in which the climate change issue is placed. The concerns include inequities in participation and decision making about agendas, inequities in funding, inequities in research infrastructure, inequities in the representation of, and barriers to acceptance of, ideas. In short, a number of the researchers are concerned about the endorsement of such an iniquitous process by the way of a global "consensus" document and the ramifications thereof.

5. SUMMARY AND CONCLUSIONS

The small but diverse community of climate researchers and analysts generally operates under significant funding constraints. Partly as a result of this, the activities of these scientists are generally targeted to issues of direct relevance to the Indian situation; unfortunately, these activities (or scientists) do not always connect in a coherent manner. Scientific networks are informal and seem to be maintained by occasional focus on specific projects. Some NGOs and academic institutions are extremely active in climate change policy analyses, though once more their focus generally revolves around (a narrowly defined set of) Indian issues. In India, scientific and policy input to the government is mostly through informal channels, and depends on the specifics of the issues and on level of interest of the people involved. To our knowledge, there are no formal assessments of the kind that seem to have proliferated in ICs, particularly the United States. The limited funding for climate activities in India does not allow for the magnitude and diversity of research and analysis that assessments need, and the climate problem deserves, especially for a country that is heavily dependent on an annual climatic event – the South Asian Monsoon.

The debate in India regarding climate change is externally driven in a number of different ways. The involvement of Indian scientists in international scientific programs related to climate has triggered the rise of a coordinated research program which targets areas of research deemed significant. Furthermore, concerns about geopolitical implications of analyses done abroad has resulted in the occasional marshaling of national (and international) resources towards scientific activities such as the Indian Methane Campaign. External funding also drives the kinds of policy analyses that get done because much of the work done by Indian analysts is funded from abroad. This allows the high profile groups involved to continue their important activities, it also significantly constrains the kinds of analysis that gets done and shapes the focus of the internal policy debate. While the international pressure on climate change has significantly shaped the kinds of research analyses that are carried out nationally, Indian analysts have had limited, if occasionally remarkable, success in shaping the international discussion[27].

The lack of formalized mechanisms for experts to connect to policy-makers (especially in the environment area) sits uncomfortably with a formal process such as the IPCC which requires an unusual amount of coordination between and among different governmental groups and the national scientific community. The review nature of the IPCC process combined with the relative paucity of internationally recognized (and internationally connected) researchers has led to low level of participation in the IPCC. Research, institutional, and other resource constraints place a large barrier to effective Indian participation in international assessment processes - even for researchers who can participate in this processes, these constraints still pose significant problems. For many of these reasons, issues pertinent to a country like India may never reach the international assessment arena, and even if brought there, may be ignored. This in turn may have serious repercussions for the national credibility of international assessments.

In the end, it must be recognized that for most LICs there are issues that are far more pressing that may swamp the signal of the climate change issue. In the case of India, economic issues are the forefront on Indian policy agendas and climate change is very low on this list of priorities. In

the international arena, when the Indian policy makers voice concern about climate change, their primary focus is on the possible (detrimental) effects of global abatement policies on economic growth.

Formal assessment processes have been termed by some as "bridges between science and policy" (Gibbons,1990). This may be true for a set of issues that are mainly scientific or technical in nature, but our experience in India shows us that for climate change, an issue which has vastly different implications between countries and within countries, the hurdles to effective national and international policy-making are not likely to be lowered significantly by building better bridges between science and policy. As the Indian case suggests, not every nation has the resource to build these bridges internally, or the resources to traverse the bridges that might be set up at the international level. In that sense, a necessary (though not sufficient) condition for an assessment to be even remotely successful is for the architects and assessors to understand the different contexts within which these assessments are being carried out and held aloft.

The Indian context suggests a number of existing gaps that international assessment production, dissemination and use could stumble over. These (non-mutually-exclusive) gaps can include:

- Resource gap
- Relevance gap
- Participation gap
- Perception gap
- Policy culture gap

The mere existence of these gaps should not lead us to believe that India's role in climate assessment has been and will continue to be marginal. Each of these gaps influence the kind of roles that countries such as India can play in shaping debate that is currently being carried out in multiple international and regional circles. In the highly contested global debate over climate change assessment, views of national success will be conditioned on what role particular countries assume and how they choose play that role. One can imagine four ways to conceive of such a role for India :as a Critic, a Collaborator, a Consumer and a Captive.

Historically, India has played the role of a critic by focusing on equity issues, sporadically challenging dominant IC views of the climate problem, and occassionally assuming a role of "Southern" leader in climate negotiations. At the same time, India has shown signs of being disengaged from the international dialogue and consequently been held captive to a debate largely shaped by IC interests. As international deliberations progress towards a climate treaty, India could serve as one critical voice for the South, a role it has long aspired for, and in which it has only occasionally been successful.

ENDNOTES

[1] The authors would like to acknowledge comments from Willam Clark, Robert Frosch, Jill Jaeger, Sheila Jasanoff, and Edward Parson. This work was funded by the Department of Engineering and Public Policy at Carnegie Mellon University, the Science,Technology and Public Policy Program (STPP) and the Global Environmental Assessment Project both at the Center for Science International Affairs, Harvard University.

[2] For example, even an international umbrella organization such as the IPCC makes no reference to the the impacts of changes in monsoons, an interannual climatic event of immense significance to large populations in Asia and Africa.

[3] Beginning in the early 1980s, structural adjustment programs (SAPs) became a fundamental part of the conditionalities imposed by the IMF/IBRD for loans to LDCs. By 1991, 187 structural adjustment loans had been disbursed.

[4] In the late 1980s and early 1990s, India was faced with a balance of payment crisis. The total government debt had reached 70% of the GDP by mid 1991, and foreign currency reserves were down to alarmingly low levels. Additionally, the US - Iraq war in the Persian gulf had reduced remittances of "hard" currency from citizens working in the Middle East, which were no longer available for servicing the foreign debt

[5] Within the energy sector, discussions have focused on a "quick-fix" solution to shortages in power, both real and perceived. Consequently, without any comprehensive analysis about the state of the power sector, state governments have been rushing pell-mell to add new generating capacity without paying much thought to a long-term strategy. Climate change issues are really not on the agenda at all in decision-making about the power sector - except to the extent that Global Environmental Facility (GEF) funds might be utilized to fund some renewables programs. Lately, international firms that have been entering India as potential IPPs (Independent Power Providers) are equally eager to sell fossil-fuel-based energy technologies paying no thought to the global warming contribution of their commercial transactions. The ENRON scandal in 1995 provides an example of short term profiteering on the part of international firms, aided and abetted by internal political misconduct.

[6] See, for example, Khan(1993)

[7] India's substantial intellectual and activist community has a history of critical analysis and action. Indian intellectuals and activists have also been swept up in the aftermath of the sweeping socio-economic changes brought about by liberalization. The efforts of the former have almost exclusively been focused on understanding the implications of these

changes for India's future, and those of the latter on attempting to mitigate the negative social impacts of drastic changes in government policy.

[8] India's policy for science has been sharply criticized for its dominantion by nuclear and defense interests (Sharma 1991).

[9] This statistic must be tempered by the large size of India's population (> 900 million). Also, "brain drain" remains a persistent problem -- a large fraction of India's best-performing scientific personnel go abroad for study or work, rarely to return.

[10] For dated but detailed view of policy related social science research in India see Weiner(1980)

[11] Much has been written about the lack of focus and fragmentation of the science community in India. Some researchers have noted that the fragmented nature is evident in the day to day practice of science (Shiva and Bandyopadhyaya, 1980). According to them, internal collaborations among scientists are infrequent, quite often colleagues in the same institution may be unaware of each others research. A number of those who do collaborate tend to do so "externally" with colleagues abroad. These collaborations are sustained by work done during sabbaticals abroad, which are an intrinsic part of the scientific incentive structure atleast in the best institutions.

[12] Generally, India's *policy for science* has been dictated by close alliances between powerful leaders and their scientific advisors. For example, the close ties between Nehru, India first prime minister and Bhabha, the creator of India's nuclear establishment set the tone for the establishment of a state science bureaucracy which focused heavily on nuclear and defense issues.

[13]Scientists had long recognized the difficulties of calculating precise aggregate emissions estimates for a gas which has a number of different non-point anthropogenic and natural sources, and whose emissions vary dramatically from location to location (Cicerone and J.Oremland 1988).

[14]A paper in Nature (Ramaswamy, M.D.Schwarzkopf et al. 1992) later showed that decreases in radiative forcing from CFC abatement would be largely offset by increases in radiative forcing from increases in ozone concentrations in the upper troposphere/lower stratosphere – a direct result of CFC abatement.

[15] The Indian Methane Campaign was the one of the first activities launched by the Indian Global Change Research Program.

[16] The EPA study was apparently aimed at characterizing the sources of methane and identifying opportunities for reducing methane emissions. The study foresaw ample worldwide potential for methane abatement at a low cost. The EPA analysis had applied emission factors derived from European and North American studies of rice emissions to them directly calculation of rice emissions from Indian sources.

[17]Many Indian scientists prefer to present their work in national journal such as *Current Science*, India's premier scientific journal because more expensive international journals are not widely available to their targeted peer group -- other Indian scientists. This could be one reason that the Indian studies of methane have not generated a broader international debate. It also reflects the satisfying conflicting constraints faced by scientists in developing countries with regards to publications of their results.

[18] Methane emissions from rice paddies were and continue to be highly uncertain. The IPCC (1990) budget provided a best guess global estimate of 100 Tg/yr (25-170 Tg/yr), close to 20% of the annual emissions from all sources More recent estimates have reduced the best guess number to 60 Tg/yr, though this clearly not as low those suggested by the work in India. These revisions reflect both a shift in methodology and the availability of new measurements (Bachelet and Nueu 1995; Kandlikar 1997) though there is little reason to believe that estimates have converged to a stable range.

[19] In the 1980s, monsoon research in India was given fresh impetus by the the advent of satellite data gathered by INSAT. The Indian Institute of Tropical Meteorology (IITM) at Pune is a widely respected center for the study of monsoon climatology, whose researchers regularly contribute sizeably to monsoon related publications in major national and international journals. For a more detailed description of India's Monsoons research see (Sikka 1992; Gadgil 1996)

[20] Consider the case of the US where the dicussions over the Superconducting Super Collider bitterly split the Physics community over the allocation of research dollars.

[21] As a matter of fact, most Indian researchers get no research funding from outside India even if they despite collabrate actively with some of the best climate research groups in the world. For complex modeling activities such as GCM modeling fast computers are essential. This makes it very difficult to do serious GCM modeling in India, which has only one supercomputer, a Cray XMP with four processors -- in which a 72-hour forecast takes 18 hours of Central Processing Unit time. Indian efforts to buy other supercomputers in the past have been blocked by the US due to concerns about sales of such strategic technology.

[22] For example, the USAID contributed significantly to a recent AIJ (Activities Implemented Jointly) conference in India, in an effort to increase the profile and build support for JI (Joint Implementation) in India. So far, the Government of India (as many other major LIC governments) has not been very warm to this idea - currently there is no US JI project in India.

[23] Two groups have published a book length document on Joint implementation in the past couple of years while a third recently organized a large international conference on the same subject.

[24] Indian scientists were and continue to be involved in research on agricultural response to climate variability. However, as climate change has come to be defined as a long term in the global issue and GCMs have become the dominant source for performing climate change impact analyses. Indian researchers who work on issues relating to short time scale climate variability have not significantly contributed to this debate.

[25] The role of networks may is generally ignored in discussions of IPCC participation (see for e.g. Banuri et al, 1995). As in most fields of research, familiarity breeds camraderie, which in turn is crucial for getting invited for involvement in activities. As a well-known Indian researcher told us, "everybody invites their friends" for participation in the IPCC.

[26] In the United States, there are mechanisms for a whole gamut of opinions to be given weight nationally (and hence internationally) in the climate change debate. At present this does not seem to be the case in India as far as climate change is concerned. As (Jasanoff 1993) has noted, there are widely divergent opinions on development and the environment in India whose holders view global environmental change through very different lenses.

[27] CSE's report on equity considerations (Agrawal and Narain 1991)comes immediately to mind.

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Report	USA	India	China	UK
IPCC '90 WGI	110	5	8	62
IPCC '95 WGI	158	3	5	61
IPCC '95 WGII	154	14	8	24
IPCC '95 WGIII	30	7	2	5

Table 1: Participating authors in IPCC reports by country. There are many levels of authorship in IPCC reports, the numbers in this table do not distinguish between them.

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